PB89-190144

Federal Policy Options for Indoor Air Pollution from Combustion Appliances

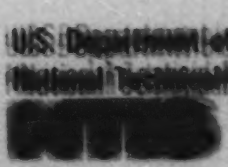
California Univ., Los Angeles

Prepared for:

Environmental Protection Agency, Washington, DC

1988

US Department of Commerce
National Technical Information Service



502.2 - 101

REPORT DOCUMENTATION PAGE	1. REPORT NO. 600/9-89/009	2.	3. PB89-190144

4. Title and Subtitle
Federal Policy Options for Indoor Air Pollution From Combustion Appliances

5. Report Date
Completed Fall 1988

6.

7. Author(s)
Lenna Kandarjian, Grqaduate Student

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
School of Public Affairs
University of Southern California
University Park-Von Keinsmid Ctr. 363
Los Angeles, CA 90089-0041

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G) U913009

12. Sponsoring Organization Name and Address
U. S. Environmental Protection Agency
Office of Cooperative Environmental Management
499 South Capitol Street, SW A101-F6
Washington, DC 20460

13. Type of Report & Period Covered
Technical Report

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

1402 FEDERAL POLICY OPTIONS FOR INDOOR AIR POLLUTION FROM COMBUSTION APPLIANCES

This report is part of the National Network for Environmental Management Studies (NNEMS) under the auspices of the Office Cooperative Environmental Management of the U. S. Environmental Protection Agency.

In fiscal year 1988 the Environmental Protection Agency spent approximately 260 million dollars to reduce the levels of pollutants in the outdoor atmosphere. For reduction of indoor pollutants, it spent only three million dollars. The average person spends over 90 percent of their time indoors, and for many contaminants, indoor concentrations exceed outdoor levels. Thus, indoor pollutants may pose a greater threat to human health than outdoor pollutants.

Energy conservation measures that result in tighter building envelopes and reduced rates of outdoor ventilation, tend to increase the concentration levels of indoor contaminant levels. Typical indoor pollutants include radon, formaldehyde, volatile organic compounds, particles, biological contaminants, and combustion gases.

This paper focuses on gas stoves, unvented gas space heaters, woodburning stoves, and kerosene heaters as representative combustion sources. The first section discusses these sources, the health problems they pose, and the physical control mechanisms to reduce indoor pollutant concentrations. The second section examines the federal policy options for indoor air pollution; summarizes the available federal, state, and local legislative authorities; defines regulatory and non-regulatory approaches to mitigate indoor air pollution; and presents possible federal actions for controlling combustion source pollutants.

17. Document Analysis a. Document Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

18. Availability Statement	19. Security Class (This Report) Unclassified	21. No. of Pages 16
	20. Security Class (This Page) Unclassified	22. Price

FINAL
1402-88
3

FEDERAL POLICY OPTIONS FOR INDOOR AIR POLLUTION FROM COMBUSTION APPLIANCES

Lenna Kandarjian
U.S. EPA Student Fellowship Program
Indoor Air Division
Office of Air and Radiation
U.S. EPA, Washington, D.C.

Public policies for the prevention and mitigation of indoor air pollution include regulatory and non-regulatory alternatives which may be administered by the federal or state and local governments, or through private sector standard setting bodies. Risks can range from life threatening risks to annoyance effects. Technical alternatives include source control, ventilation control, and air cleaning alternatives, while indoor air settings may be residential or commercial. Therefore, agents of control may be the manufacturer, the building or establishment owner, or the consumer/user. The paper characterizes indoor combustion appliance sources of indoor air pollution, and, discusses policy options for controlling risks in light of current legislative authorities. Policy options are grouped according to the agent of control.

Disclaimer

This report was furnished to the U. S. Environmental Protection Agency by the graduate student identified on the cover page, under a National Network of Environmental Policy Studies fellowship.

The contents are essentially as received from the author. The opinions, findings, and conclusions expressed are those of the author and not necessarily those of the Environmental Protection Agency. Mention, if any, of company, process, or product names is not to be considered as an endorsement by the U. S. Environmental Protection Agency.

INTRODUCTION

In fiscal 1988 the Environmental Protection Agency spent approximately $260 Million to reduce the levels of pollutants in the outdoor atmosphere. For indoors, it spent only $3 Million. However, on average, the public spend over 90 percent of their time indoors, and, for many contaminants, indoor concentrations exceed outdoor levels. Thus, indoor pollutants may pose a greater threat to human health than outdoor pollutants.

Typical indoor pollutants include radon, formaldehyde, volatile organic compounds, particles, biological contaminants, and combustion gases. The rise in energy prices in the 1970's stimulated the use of many additional combustion sources as both primary and supplementary sources of heat. In addition, energy conservation measures, many of which were encouraged by the Energy Policy and Conservation Act of 1976, resulted in tighter building envelopes and reduced rates of outdoor ventilation, and tended to increase indoor concentrations of indoor contaminants. These factors have combined to make indoor air pollution a subject of growing public concern.

This paper focuses on gas stoves, unvented gas space heaters, wood-burning stoves and kerosene heaters as representative combustion sources. The first section discusses these sources, the health problems they pose, and the physical control mechanisms to reduce indoor pollutant concentrations. The second section examines the federal policy options for indoor air pollution, summarizes the available federal, state, and local legislative authorities, defines regulatory and non-regulatory approaches to mitigate indoor air pollution, and presents possible federal actions for controlling combustion source pollutants.

CHARACTERIZING COMBUSTION APPLIANCES

Combustion sources are important contributors to indoor pollution. They simultaneously consume oxygen and emit contaminants to indoor spaces. The contaminants associated with each of the combustion appliance sources are displayed in Table 1. They include: Benzo[a]pyrene (BaP) and other polynuclear aromatic hydrocarbons (PAHs), carbon monoxide (CO), carbon dioxide (CO2), formaldehyde (HCHO), nitrogen oxide (NO), nitrogen dioxide (NO2), nitric oxide (NOx), respirable suspended particulates (RSP), and sulfur dioxide (SO2). This section discusses combustion appliance sources, its effects on health, and physical control mechanisms.

TABLE 1

POLLUTANTS EMITTED BY COMBUSTION APPLIANCES

SOURCES	POLLUTANTS							
	B(a)p	CO	CO2	HCHO	NO	NO2	RSP	SO2
Gas-fired range		x	x	x	x	x	x	
Unvented gas space heater		x	x	x	x	x	x	
Wood-burning stove	x	x	x	x	x		x	
Kerosene heater		x	x	x	x	x	x	x

Source: Adapted from reference 19.

Combustion Appliance Sources

Gas-Fired Ranges:

Approximately 46 percent of U.S. homes use a gas range for cooking (3). Most of these ranges are not vented to the outside, thus, the contaminants are emitted directly to indoor spaces. Factors which contribute to gas range emission rates include the pattern of usage, burner design, age of burner, fuel-consumption rate, and combustion efficiency (19).

New technologies are being developed to reduce emissions from gas fired ranges. For example, an infrared range top burner has demonstrated a considerable reduction of NO2 emissions, and is 50% more efficient than conventional burners. The infrared burner is currently undergoing field tests and will be available to the public in the near future (3).

Unvented Gas Space Heaters:

About 7 percent of U.S. homes use unvented gas space heaters (3). Emission rates are affected by usage pattern, brand of heater, burner design, size of heater, and its state of tuning (19). Proper tuning of the appliance can reduce the emissions of CO, NO2, and HCHO (16). While reducing the flame can decrease NO and total NOx, it also increases CO and NO2 emissions (19).

Wood-Burning Stoves:

Higher heating costs have made wood-burning stoves increasingly attractive to the public. Approximately 12 to 14 million households in the United States use wood-burning stoves (22). Stove design, operating style, installation practices, the degree of maintenance, the existence of cracks or leaks in stovepipes, the presence of down-drafts, and the type and amount of wood burned will affect the rate of emissions. Emissions are usually highest during start-up and reloading (15,19).

Kerosene Heaters:

Approximately 7 million kerosene heaters are used indoors in the United States (2). Factors which affect emissions include usage pat-tern, manufacturer and type of heater (convective, radiant, or wickless), wick adjustment, fuel type and consumption rate, and age of heater. Wick adjustment is important in adjusting the flame. A flame which is too high can cause soot and odor, while a low flame can produce excessive CO (19).

Kerosene heaters can produce excessive amounts of SO2 if used with sulfur containing fuels. Consumer Reports recommends the use of K-1 fuel which has a low sulfur content. However, the availablility of K-1 fuel may be limited in some areas.

Health Effects of Combustion Appliances

Combustion pollutants have been associated with a variety of human health problems ranging from mild irritation of the skin, eyes, nose and throat to death. The nature and the effects of each pollutant are summarized in Table 2.

TABLE 2

ADVERSE HEALTH EFFECTS BY POLLUTANTS
EMITTED FROM COMBUSTION APPLIANCES

	B(a)P	CO	CO2	HCHO	NOx	RSP	SO2
Affects alertness		x	x				
Affects vision		x	x				
Affects perception		x					
Affects learning ability		x					
Birth defects (low birth weight)		x		x			
Blocks oxygen		x			x		
Blood effects		x		x			
Bronchitis					x	x	
Cancer	x						
Coma		x					
Confusion		x					
Damage to a fetus		x					
Death		x			x		
Diarrhea		x		x			
Dizziness		x		x			
Drowsiness		x	x				
Emphysema						x	
Headaches		x	x	x			
Heart problems		x				x	
Irritation of the skin, eyes, nose and throat				x	x	x	x
Liver/kidney effects		x					
Menstral disorders				x			
Nausea		x					
Pulmonary function disorders				x	x		
Increased susceptibility to respiratory infections				x	x	x	
Reduces lung growth					x		
Sleep disruption		x					
Tumor	x						
Vomiting		x		x			

Source: Adapted from references 19 & 20.

- Carbon monoxide (CO) is a poisonous gas. It blocks the delivery of oxygen throughout the body. It affects alertness, vision, perception, learning ability, and disrupts sleep. It can cause drowsiness, nausea, confusion and damage to a fetus. At very high concentrations, it can cause coma and death (19,20).

- Carbon dioxide (CO2) in the blood regulates the breathing rate. A slight elevation of CO2 in the blood causes an increase in the breathing rate. At high concentrations, it affects the blood acidity, and, at chronic elevation it produces compensatory removal by the kidneys (19,20). Increased concentrations of CO2 in a building can cause drowsiness, headaches, and it can decrease alterness.

- Nitrogen oxides (NO) cause increased susceptibility to acute respiratory infections. It impairs chemical and functional properties of membranes, reduces lung growth, and increases liver dysfunction. NOx with hemoglobin in the blood, forms methemoglobin which reduces oxygen carrying capacity of the blood (19,20).

- Sulfur dioxide (SO2) concentrations can irritate the skin, eyes, nose and throat, and it is known to cause significant bronchoconstriction in exercising asthmatics, depending upon the concentration levels of SO2 indoors. Otherwise, SO2 has no direct health effects (19).

- Formaldehyde (HCHO) gas is an animal carcinogen. Exposure to formaldehyde can cause irritation of the eyes, nose, and throat, diarrhea, vomiting, headaches, and dizziness. Long term exposure can cause menstrual disorders, decreases in pulmonary function, low infant birth weight, and cancer of the liver, larynx, pharynx and oral cavity of animals (19,20).

- Depending on the size of particles and the chemical composition RSP can cause irritation of the eyes, nose and throat, and respiratory infection, bronchitis, emphysema and heart disease (19,20).

Physical Control Options for Indoor Pollutants

Mechanisms to control indoor air pollution include: source control, ventilation control, and air cleaning.

Source control:

Methods of source control include: removal, modification, operation and maintenance.

Removal of a combustion appliance from the indoor atmosphere would obviously eliminate pollutant emissions. However, this strategy would be most effective when a substitute is available. For example, a gas-range may be substituted by an electric range.

Modifying a product may reduce the emissions of some pollutants. For example, inserts for gas range burners, ovens and other gas appliances can reduce gas emissions and particulates. In addition, changing the design of a gas range can reduce emissions by venting the oven outdoors rather on top of the range.

Proper operation and maintenance of an appliance can reduce the levels of the pollutants emitted. For example combustion appliances generally emit lower levels of pollutants with the proper fuel type, and proper tuning and maintenance. These are necessary to insure a clean burn and the efficient exhaust of flue gasses.

Ventilation control:

General ventilation controls indoor air pollutants by diluting indoor air with outdoor air. Its effectiveness depends on the extent to which outdoor pollutant concentrations are less than those indoors. General ventilation can be natural or mechanical. Natural ventilation occurs when air flows through cracks and openings in the building shell, and by opening doors and windows. Mechanical ventilation is the mechanical movement of air through a building where outdoor air is introduced through outdoor air dampers.

Local ventilation in the vicinity of a pollutant source is a source specific ventilation control technique. This strategy, also called exhaust ventilation, typically provides a separate exhaust for the plume of pollutants emitted from the source. To the extent that it decreases source strength, it may also be regarded as a source control strategy.

Air Cleaning:

Air cleaning removes indoor air pollutants (particles not gases) by particulate filtration, electrostatic precipitation, and gas or vapor sorption.

Particulate filtration is a method designed to remove particles by passing air through a filter. Filters vary in effiency and may be used for different purposes. For example, low efficiency filters remove coarse particles and are often used upstream as prefilters to protect air handling equipment, or to improve the longevity of more efficient filters. Extremely efficient filters, such as HEPA filters may be used in special facilities such as a surgical suite, or for the protection of health sensitive individuals.

Electrostatic precipitators induce an electrical charge on particles and then collect the particles on oppositely charged surfaces. Electrostatic precipitators are commonly used in HVAC systems. Potential hazards include the production of ozone.

Gas or vapor sorption processes include a number of different technologies, which are often designed for the specific chemical of concern. Sorbents include neutral substances such as activiated carbon, or selective substances such as activated alumina and silica. Gas or vapor sorption can be expensive, and are generally not regarded as practical in typical residential or commercial environments.

Federal Legislative Authorities

Several federal laws deal with indoor air quality. They include: Consumer Product Safety Act; Toxic Substances Control Act; Energy Conservation and Production Act; Energy and Conservation Act; Title IV of the Superfund Amendments and Reauthorization Act (SARA); and the newly proposed indoor air quality legislation (S.1629). This section presents a summary of the Acts and S.1629.

Consumer Product Safety Act (CPSA):

The Act grants the Consumer Product Safety Commission (CPSC) the authority to regulate consumer products that emit pollutants in the indoor atmosphere. However, the Act limits the authority of CPSC to control consumer products. Moreover, it does not vest authority to establish indoor air quality standards or ventilation standards.

Toxic Substances Control Act (TSCA):

TSCA grants EPA the authority to require the testing of chemicals which present an unreasonable risk of injury to health and the environment. Thus, EPA could use TSCA to restrict the manufacture and distribution of certain products, and the use of toxic chemicals that are emitted in the indoor atmosphere.

Energy Conservation and Production Act:

The Act authorizes the Department of Energy (DOE) to develop voluntary performance standards for energy efficient residential and commercial buildings. The Act provides technical assistance for implementing those standards, and it encourages states and local governments to incorporate those standards in building codes. The Act also requires DOE to undertake a residential weatherization assistance program.

Energy Policy and Conservation Act:

The Act provides federal financial assistance to the public and the private sector to develop energy conservation programs. It establishes regulatory programs to bring about measured savings in consumption of energy by improving the efficiency of major appliances, and certain other consumer products.

SARA Title IV

SARA Title IV requires EPA to establish a research program for the study of radon gas and indoor air quality. The design purpose of such a program is to gather information on all aspects of indoor air, coordinate government and private sector research, and assess appropriate federal actions to mitigate indoor air associated risks.

Proposed Indoor Air Quality Legislation: (S 1629)

An indoor air quality bill (S 1629) was recently introduced in Congress by Senator Mitchell. The bill is a non-regulatory approach to the problem of indoor air. The bill authorizes EPA to conduct research,

coordinate indoor air quality activities, and dissiminate information. The bill also, identifies some specific actions of the public and the private sector. Given the importance of this legislation, these identified actions are summarized in Table 3.

TABLE 3

ACTIONS SPECIFIED IN S.1629

	Federal	State	Local	Private Sector
Research & development	x	x	x	x
Information dissemination	x	x		
Training & tech assistance	x			
Make grants to states, localities and other organizations for R&D	x			
Health advisories	x			
Develop response plan	x	x	x	
Model building codes	x			
Federal building controls	x			
New model EPA building	x			

State and Local Authority: Building Codes

Building codes can deal with indoor air pollution problems that are caused by the way a structure is built. For example, building codes can set ventilation standards, ban certain building materials, or set product design standards.

Building codes are a state and local responsibility. The adoption and enforcement of codes is an exercise of governmental "police power", and under the Tenth Amendment of the United States Constitution, police power is reserved to the states. Localities have no inherent police power, however, they often do exercise such power through state statutes.

States and municipalities often lack the resources for technical research, testing and evaluation for drafting a building code. Thus, they often adopt model documents from one of the three primary model code groups. These groups are: the Building Officials and Code Administrators' International (BOCA), the International Conference of Building Officials (ICBO), and the Southern Building Code Congress International (SBCC).

In the past, federal agencies have substantially influenced building standards. For example, the Department of Housing and Urban Development cooperated with the mobile home manufacturers for increased regulation of their products in order to develop uniformity in regulation. Thus, state regulation were preempted and federal mobile home standards were enacted in 1974. In addition, under the Energy Policy and Conservation Act of 1976, the Department of Energy cooperated with the three major model building code groups through a contract with the National Conference of States on Building Codes and Standards. Thus, together they developed a model code for energy efficiency.

A model building code for indoor air quality can be developed by EPA in cooperation with other federal agencies, (HUD, DOE, CPSC) and states and building organizations. A model building code would set standards for the minimum ventilation rates, the product emissions, building materials, and building design. Moreover, a model code would create uniformity and would guide states and localities to revise the building codes.

Administrative Control Options: Regulatory and Non-Regulatory

Administrative control options can be regulatory or non-regulatory. The regulatory approach imposes requirements on individuals and manufacturers, whereas, the non-regulatory approach does not. Thus, administrative control options may be as mild as public education or as stringent as an absolute ban on the use of a product. This section discusses regulatory and non-regulatory administrative control options.

Regulatory options:

Regulations are authorized by a specific legislation. The most common types of regulations are those which are specific to a given pollutant or source. Regulations could ban or restrict the use of a specific chemical or a product, require products to meet certain standards, products be tested and certified prior to manufacture, and lastly be labelled with important information concerning content, effects, and proper instructions for use.

Some regulatory requirements may be in the form of standards or guidelines, and they are frequently issued by the public as well as the private sector. Standards and guidelines relevant to indoor air include: air quality standards, source emission standards, ventilation standards, and building codes.

Non-regulatory options:

Non-regulatory instruments include: research, coordination, public education, training and technical assistance and public information. Research helps determine the magnitude of the problem. Coordination helps ensure the implementation of the policy by defining the role of each player. Training and technical assistance provides individuals with technical information to help them develop the tools to implement the objectives of the policy. Public information provides individuals with information so that they can take action to reduce exposure and risk.

Possible Federal Actions To Control Combustion Pollutants

Federal actions to control combustion pollutants could be regulatory or non-regulatory. Regulatory actions would most likely be administered by the Consumer Product Safety Commision under the authority of the Consumer Product Safety Act. Non-regulatory actions would be administered by EPA, DOE, HUD, or other governmental agencies. This section identifies the role of manufacturers, users, and building designers, and presents the possible policy options by manufacturer controls, user controls, and building controls.

Manufacturer Controls:

Manufacturers can play a significant role in controlling combustion pollutants. The federal government could work cooperatively with manufacturers to institute several types of changes to reduce product emissions, or, if necessary, manufacturers could be required to institute changes. For example:

- Gas stove manufacturers could change stove designs by using infrared burners, provide more efficient or automatically actuated exhausts, and exhaust fans could be made less noisy to encourage their use.

- Wood stove manufacturers could redesign wood stoves using catalytic converters and double-combustion chambers to reduce combustion emissions.

- Manufacturers of space heaters could be banned from selling unvented products, or,

- Emission standards for individual products could be developed either voluntarily or through regulation, with administrative mechanisms to insure that such standards are met.

User Controls:

User behavior is an important determinant of combustion appliance emissions. However, users may be ignorant of their role in controlling their own exposure, or the exposure of others sharing the indoor space. Thus, several policy options center around providing users with information. This can be done in a variety of formats, which may be either regulatory or voluntary. For example:

- Manufacturers could label products as to proper operation, maintenance, and tuning, and methods of flame adjustment to insure minimal emissions.

- Manufacturers could provide instructions to the user as to proper installation and use, and could educate retailers and distributors.

- Government can provide information directly to the public and could support public information programs of consumer and public health organizations. One option, for example, might be a public information clearing house.

Building Controls:

The design, operation, and maintenance of buildings, particularly air exchange rate, or provisions for local ventilation usually affect indoor air quality from combustion appliances. Building design changes can be made by architects, builders and engineers, and may be included in building codes administered by state and local governments. For example:

- Building codes could require both a window and an exaust fan in residential kitchens.

- Builders could offer special provisions for exhausting supplemental heat sources such as kerosene heaters and wood stoves, and could provide special outside air dampers as supply air to support combustion for furnaces and fireplaces.

- Building codes could require contaminant sensors, similar to smoke detectors, to be provided in areas where combustion sources may be present.

SUMMARY

This paper discussed gas-fired ranges, unvented gas space heaters, wood-burning stoves and kerosene heaters, their contributions to indoor pollution, their association with human health problems, and the available physical and administrative control mechanisms to reduce indoor pollutant concentrations. The paper also presented three types of policy options to control combustion pollutants: manufacturer controls, user controls, and building controls.

REFERENCES

1. Apte, M.G., and Traynor, Gregory, G.W., "Comparison of Pollutant Emission Rates From Unvented Kerosene and Gas Space Heaters," Presented at ASHRAE conference, 1986.

2. Consumer Product Safety Commission, "What You Should Know About Kerosene Heaters," August, 1987.

3. Gas Research Institute, "Indoor Air Quality Research", undated pamphlet, Chicago, Illinois.

4. Kirsch, Laurence, S., "Behind Closed Doors: Indoor Air Pollution and Government Policy," The Harvard Environmental Law Review, Vol., 6, No., 2, 1982.

5. Senate Bill on Indoor Air Quality, (S.1629), Held in Senate Committe on Environment and Public Works.

6. Mudarri, David, H. "Toward a National Strategy for the mitigation of indoor air pollution," Air Pollution Control Association, Minnesota, June, 1986.

7. National Bureau of Standards, An Economic Analysis of Building Code Impacts A Suggested Approach, October, 1978.

8. Sexton, Ken, "Public Policy Implications of Exposure to Indoor Pollution," prepared for the U.S. Environmental Protection Agency.

9. Sexton, Ken, "Indoor Air Quality: An Overview of Policy and Regulatory Issues," Science, Technology, Human values, Winter, 1986.

10. Sexton, Ken, and Repetto, Robert, "Indoor Air Pollution and Public Policy," Environmental International, Vol., 8, 1982.

11. Sexton, Ken, and Spengler, John, D., "Indoor Air Pollution: A Public Health Perspective," Science, Vol., 221, No. 4605, July, 1983.

12. Thompson, Grant, P., Building to Save Energy: Legal and Regulatory Approaches, Ballinger Publishing Company, 1980.

13. Traynor, Gregory, W., "Field Monitoring Design Considerations for Assessing Indoor Exposures to Combustion Pollutants," Atmospheric Environment, Vol., 21, No. 2, 1987.

14. Traynor, Allen, Apte, Girman, and Hollowell, "Pollutant Emissions from Portable Kerosene-Fired Space Heaters," Environmental Science & Technology, Vol., 17, June 1983.

15. Traynor, Apte, Carruthers, Dillworth, Grimsrud, and Gundel, "Indoor Air Pollution due to Emissions from Wood-Burning Stoves," Environmental Science & Technology, Vol., 21, July, 1987.

16. Traynor, Girman, Apte, Dillworth, and White, "Indoor Air Pollution Due to Emissions from Unvented Gas-Fired Space Heaters," APCA Journal, Vol., 35, NO., 3, March, 1985.

17. Traynor, Apte, Carruthers, Dillworth, Grimsrud, and Thompson, "Indoor Air Pollution and Inter-Room Pollutant Transport Due to Unvented Kerosene-Fired Space Heaters," Environmental International, Vol., 13., 1987.

18. U.S. Department of Energy, Indoor Air Quality Information Handbook: Building Systems Characteristics, January, 1987.

19. U.S. Department of Energy, Indoor Air Quality Information Handbook: Combustion Sources, January, 1985.

20. U.S. Environmental Protection Agency, Report to Congress on indoor air quality, Vol., III, Assessment and Control of Indoor Air Quality, June, 1988.

21. U.S. Environmental Protection Agency, EPA Indoor Air Quality Implementation Plan: Appendix A., Preliminary Indoor Air Pollution Information Assessment, June, 1987.

22. Wood Heating Alliance, Washington, D.C. Telephone conversation, on September 9, 1988.

23. 42, U.S.C., section 6201-6422, The Energy Conservation Act (1976).